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(71) Applicant: **IceCure Medical Ltd.**
3088900 Caesarea (IL)

(72) Inventors:
- **MUCHNIK, Naum**
  2067633 83 Hermon Street, Yokneam Illit (IL)
- **HILLELI, Ron**
  3095306 3 Af Al Pi Chen Street, Zichron Yaacov (IL)
- **KAUFMAN, Shai**
  4584500 Nir Eliyahu (IL)
- **LASKER, Lior**
  2 Elyahu Hakim Street, Apt. 20, Haifa (IL)
- **WEISER, Adir**
  101 Hatavor Street, Nofit (IL)

(74) Representative: **Beck Greener LLP**
Fulwood House
12 Fulwood Place
London WC1V 6HR (GB)

(54) CRYOGENIC SYSTEM CONNECTOR

(57) A cryogenic apparatus, consisting of a connector that has a connector base plate configured for connection to a conduit carrying a cryogen, and a slot extending across the base plate. The apparatus has a plug, which is configured for insertion into an opening in the base plate. The apparatus also has a latch plate that is configured to slide within the slot between a first position, in which the plug is inserted through an aperture in the latch plate into the opening, and a second position, in which a cryogenic probe is inserted through the aperture and brought into fluid communication with the opening. There is a sensor, which is coupled to control a flow of the cryogen through the conduit by detecting whether the latch plate is in the first position or the second position.

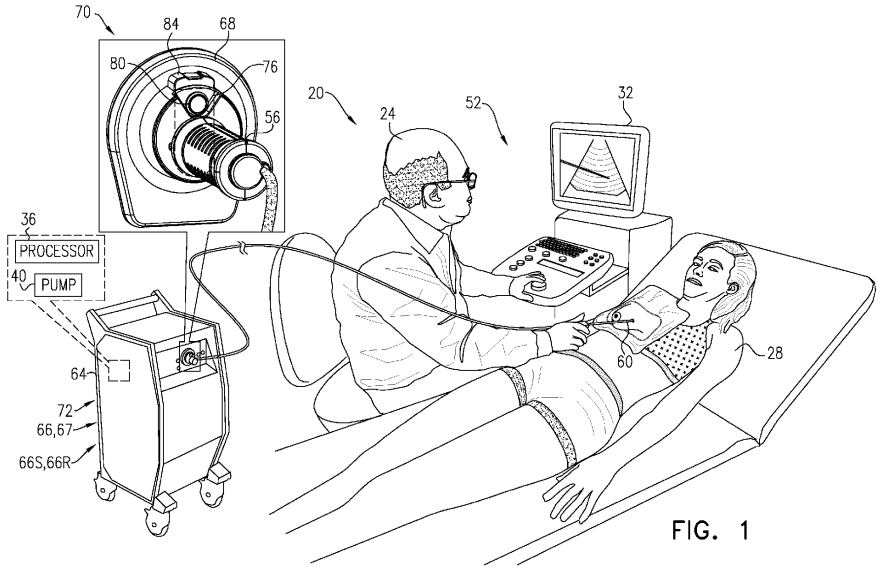

FIG. 1

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Description

[0001] This invention relates generally to cryogenics, and specifically to connecting entities used in a cryogenic system together.

[0002] Entities used in a cryogenic system, such as a Dewar or a medical probe, are typically well-insulated to reduce evaporation of cryogen, and are also typically well-sealed to prevent ingress of elements such as moisture. In order to connect the entities, any connector should provide the same properties of good insulation and sealing, while permitting connection and disconnection of the entities.

[0003] US3,845,974 describes a coupling device for a line conduit conveying cryogenic liquids. The device is stated to be of the easy make-and-break type and to comprise two connectable coupling bodies.

[0004] US3,988,029 describes a coupling device for cryogenic fluids which allows passage of liquid and vapor simultaneously through one coaxially arranged assembly. The device is stated to have low heat transfer insulation integral with the coupling and also the ability to connect and disconnect without use of tools.

[0005] US4,107,946 describes an interface for a magnet Dewar which includes a low leakage disconnect fitting that retains the vacuum integrity of both the Dewar and a connected transfer line.

[0006] US5,363,879 describes a coupling assembly for dispensing cryogenic fluids. The assembly has an upstream terminus coupled to a source of cryogenic fluid and a downstream terminus connected to a container for receiving the cryogenic fluid. A poppet valve assembly is disposed at the upstream dispensing terminus.

[0007] US5,429,155 describes a cryogenic fluid coupling that has a male half and a female half. Each half has a poppet valve arranged to move toward and way from a seat. The male half has an outer sleeve which is adapted to guide initial joinder of the female half distal end.

[0008] US5,452,582 describes a cryo-probe wherein refrigerant is furnished from a high pressure, room temperature supply. Refrigerant flows through a pre-cooling heat exchanger in the probe and through a restrictor wherein the pressure drops.

[0009] US5,946,920 describes controlling the flow rate of a liquid cryogen by controlling variably the pressure propellant gas acting directly or indirectly on the liquid cryogen.

[0010] US5,957,918 describes a cryosurgical instrument having a Dewar and a cap which is threaded onto the Dewar when in use, with a main valve portion secured to the cap by threads. The handedness of the threads on the main valve portion are opposite to the handedness of the cap threads.

[0011] US6,035,646 describes a liquid cryogen withdrawal device that includes a plug for insertion into the neck of a cryogen-containing Dewar in a gas-tight relationship.

[0012] US6,082,400 describes a coupling for connecting vacuum-insulated line ends via a coupling socket and a coupling plug. The socket and the plug are provided for conveying a cryogenic medium and have closing elements.

[0013] US6,145,322 describes a cryogenic coupler that includes a socket and a plug that can be detachably inserted into the socket. The socket and the plug have passages for passing a cryogenic medium therethrough, and are provided with valves for blocking the respective passages when the plug is disconnected from the socket.

[0014] US6,183,019 describes a coupling device that can connect two cryogenic fluid conduits in fluid communication without creating a temperature change. The coupling device is stated to have a fluid flow path with a substantially constant cross-sectional area. The coupling device is stated to be designed to be easy to connect and disconnect and to provide a secure connection, in particular at a low temperature.

[0015] US6,945,477 describes a cryogenic coupling device that includes a valved receptacle and a valved nozzle. Rollers in an outer collar of the receptacle are received in helical channels along a collar of the nozzle. A notch or detent in each of the channels provides a vent position to vent fluid before the nozzle is fully disconnected from the receptacle.

[0016] US7,128,347 describes a quick connector coupling for forming a joint in a fluid line system. The quick connector coupling has a female connector body, a male member and a latch coupled to the connector body.

[0017] US7,189,228 describes a disposable probe assembly that includes a breakaway collar. The collar, when twisted away, activates a finger lock element.

[0018] US7,381,207 describes a quick disconnect assembly that includes a reusable assembly including a distal end having a male lip. There is a disposable assembly having quick disconnect capabilities when utilized with the reusable assembly.

[0019] US7,469,718 describes a cylindrical quick disconnect female cryogenic coupler, interconnected with a cryogenic fluid transfer apparatus. The coupler includes a coupler body with a first cavity housing a laterally severed tubular bushing, and an adaptor having one end attached to the coupler body and another end to the apparatus.

[0020] US8,092,448 describes a liquid cryogen fluid system for providing cryogenic liquid to a cryoprobe. Flow of cryogen from a cryogen source to the cryoprobe is induced by pressurizing the cryogen source with air delivered by a pressurization pump.

[0021] US8,517,749 describes an apparatus that enables quick disconnect termination or connection for cryogenic transfer lines. The apparatus is a connector that will allow two lines to be connected and coupled to simultaneously allow fluid flow to occur and electrical communication to ensue. The connection and termination are stated to occur successfully under a pressurized environment.

[0022] US8,784,409 describes a cryogenic medical device for delivery of subcooled liquid cryogen to various configurations of cryoprobes. The device is a closed or semi-closed system in which the liquid cryogen is contained in both the supply and return stages.

[0023] US10,022,175 describes a first pliable element defining a cooling chamber and a second pliable element which partially encloses the first pliable element, thereby defining a junction between the first and second pliable element. A check valve is included which is in fluid communication with the junction.

[0024] US10,054,262 describes a cryogenic system that includes a reservoir containing a liquid cryogen and a sub-cooling coil immersed in the liquid cryogen. The cryogen is supplied to the sub-cooling coil and is cooled under pressure to produce a pressurized mixed phase cryogen within the sub-cooling coil. This pressurized mixed phase cryogen is provided via a supply line to a cryo-device for use by the device.

[0025] US10,159,522 describes a device, for freezing body tissue, having a main driving system capable of generating nitrogen under physical conditions near a critical point of a liquid-vapor system for the nitrogen.

[0026] US10,531,656 describes a liquid nitrogen delivery and flow regulation system that may be used to regulate the temperature of a cold cavity. Liquid nitrogen is delivered to a liquid nitrogen boiler from a storage Dewar. The Dewar is filled through a coupling connector attached to a feed-line that enters into a manifold. Liquid nitrogen inflow to the Dewar is regulated by an electrically controlled valve that receives signals from a control board on a control line. During the Dewar filling cycle, internal back-pressure in the Dewar is released by an electrically controlled gas release valve that is operated by a signal control line.

[0027] US10,859,211 describes a vapor plug, which partially seals an opening of a Dewar. The vapor plug includes a vapor plug cover which is configured to cover an opening of the Dewar. The vapor plug includes a neck that is formed from multiple disks and multiple sheets. The vapor plug includes a fastener that connects the multiple disks, the multiple sheets and the vapor plug cover.

[0028] US2004/0024392 describes apparatus for delivery of cryosurgery fluid in a surgical or other medical environment. The apparatus comprises a multiple-layered expanded polytetrafluoroethylene conduit that has a low profile, has low thermal conductivity, and is stated to provide exceptional flexibility.

[0029] US2019/0390822 describes a supply line that supplies cryogenic liquid to a plurality of cryogenic freezers. A fill line having a diameter greater than the supply line allows a storage tank to be filled at a greater speed relative to filling through the supply line and allows the storage tank to be filled while supplying cryogenic liquid to the cryogenic freezers.

[0030] CN203641719U describes a connector connecting a gas storage tank and a Dewar. The connector has a threaded sleeve piece used for connecting with a fluid outlet of the gas storage tank. There is a corresponding connector body used for filling of the Dewar.

[0031] GB2321531A describes an infra-red radiation detector having a Dewar type vessel. The detector has a coupler which is coupled to the wall of the vessel. The coupler includes a fibre which can transmit infra red radiation and which terminates close to a detector provided in the Dewar type vessel

[0032] According to an aspect of the present invention, there is provided a cryogenic apparatus, comprising: a connector having a connector base plate configured for connection to a conduit carrying a cryogen and a slot extending across the base plate; a plug, which is configured for insertion into an opening in the base plate; a latch plate configured to slide within the slot between a first position, in which the plug is inserted through an aperture in the latch plate into the opening, and a second position, in which a cryogenic probe is inserted through the aperture and brought into fluid communication with the opening; and a sensor, which is coupled to control a flow of the cryogen through the conduit by detecting whether the latch plate is in the first position or the second position.

[0033] In embodiments, the plug has a groove, and the aperture grips the groove, when the plug is inserted through the aperture, so as to lock the plug to the latch plate.

[0034] In embodiments, the cryogenic probe has a groove, and the aperture grips the groove, when the probe is inserted through the aperture, so as to lock the probe to the latch plate.

[0035] In embodiments, there is a control rod which penetrates a further aperture in the latch plate and which is configured to operate the sensor.

[0036] In embodiments, there is a control rod which penetrates a further aperture in the latch plate and which, when the latch plate is in the first position, is in a first control rod position that deactivates the sensor so as to prevent flow of the cryogen, and when the latch plate is in the second position, is in a second control rod position that activates the sensor so as to permit flow of the cryogen.

[0037] In embodiments, there is a control rod which penetrates a further aperture in the latch plate and which, when the latch plate is in the first position, is in a first control rod position that prevents the latch plate from moving from the first position, and when the latch plate is in the second position, is in a second control rod position that prevents the latch plate from moving from the second position. Preferably, the control rod, when translated from the first control rod position permits the latch plate moving from the first position, and, when translated from the second control rod position permits the latch plate moving from the second position.

[0038] According to another aspect of the present invention, there is provided a method, comprising: providing a connector having a connector base plate configured for connection to a conduit carrying a cryogen and a slot

extending across the base plate; configuring a plug for insertion into an opening in the base plate; sliding a latch plate within the slot between a first position, in which the plug is inserted through an aperture in the latch plate into the opening, and a second position, in which a cryogenic probe is inserted through the aperture and brought into fluid communication with the opening; and coupling a sensor to control a flow of the cryogen through the conduit by detecting whether the latch plate is in the first position or the second position.

[0039] The present disclosure will be more fully understood from the following detailed description of the embodiments thereof, taken together with the drawings, in which:

Fig. 1 is a schematic illustration of an apparatus being used for a cryogenic medical procedure;

Figs. 2A and 2B are schematic drawings of a connector of the apparatus;

Fig. 3 is a schematic drawing of the connector when a proximal termination of a probe is inserted into the connector; and

Fig. 4 is a schematic drawing of the connector when a sealing plug is inserted into the connector.

Overview

[0040] In a medical cryogenic procedure, it is important, from a safety point of view, to maintain the cryogen isolated and sealed from the surgeon performing the procedure, and from the patient undergoing the procedure, so that neither have any direct exposure to the cryogen. The procedure typically involves connecting and disconnecting a probe, which in some embodiments may be a sterile disposable probe, used for the procedure from a Dewar storing the cryogen, and at both times there may be leakage of the cryogen. In addition, when the probe is disconnected from the Dewar, it is important to seal the connection to the Dewar to reduce evaporation of the cryogen, to prevent ice forming on the connection, and to prevent expulsion of the cryogen from the Dewar. While speed and simplicity of operation is important for connecting and disconnecting the probe, as well as for sealing the connection, it is equally important, if not more so, that these actions cannot occur inadvertently.

[0041] Embodiments of the invention address these considerations by providing a connector to a Dewar storage unit that has a pump for the stored cryogen. The connector, together with a latch incorporated in the connector, has three states: a sealed state, which has a sealing plug in the connector, an active state, when the probe is in the connector, and an intermediate state when neither the sealing plug nor the probe are in the connector. Change from the intermediate state to either the sealed state or the active state, by respective insertion of the sealing plug or the probe into the connector, is fast and simple, and may be accomplished with only one hand. Once inserted, the latch locks the probe or the plug in place, so that inadvertent removal is not possible.

[0042] In addition, for safety, there is an activation mechanism attached to the latch so that removal of the plug or the probe requires initially operating the mechanism with two fingers of one hand, so as to free the plug or probe. Once freed, the other hand may extract the plug or probe. Also for safety, the mechanism is configured to detect the presence of the plug and the probe when they are inserted into the connector, by activating respective sensors indicating the presence of the plug or of the probe. Detection of the presence of the plug renders the Dewar pump inoperative, but when the presence of the probe is detected, the pump may be operated.

Detailed Description

[0043] In the following description, like elements in the drawings are identified by like numerals. In addition, all directional references (e.g., upper, lower, upward, downward, left, right, top, bottom, above, below, vertical, and horizontal) are only used for identification purposes to aid the reader's understanding of the present invention, and do not create limitations, particularly as to the position, orientation, or use of embodiments of the invention.

[0044] Reference is now made to Fig. 1, which is a schematic illustration of an apparatus 20 being used for a cryogenic medical procedure, according to an embodiment of the present invention. By way of example the procedure assumed in the following description is on a breast tumor, but it will be understood that apparatus 20 may be used for other procedures, such as on a prostate or kidney tumor, and all such procedures are considered to be comprised within the scope of the present invention.

[0045] The procedure is performed by a physician 24 on a patient 28, and the physician has inserted a distal end 52 of a probe 60 into the patient. Typically, probe 60 is non-disposable, as is assumed in the following description. In some embodiments probe 60 comprises a sterile disposable probe, and those having ordinary skill in the art will be able to adapt the following description, *mutatis mutandis,* for this type of probe. The physician may observe an image of the procedure on a screen 32.

[0046] A proximal termination 56 of the probe is inserted into an opening 70 in a connector 68 of a cryogen storage unit 64. Storage unit 64 is operated by a processor 36, and, *inter alia,* comprises a cryogen pump 40 and a cryogen delivery section 66, both of which are under control of the processor. In one embodiment delivery section 66 comprises a cylindrical lumen 67, also herein termed a conduit 67, having a plurality of different diameters. Section 66 and conduit 67 are illustrated in Fig. 2B.

[0047] A distal end of termination 56 is configured to mate with conduit 67, the distal end acting as a male section and the lumen as a female section. Once mated, the combination forms a cylindrical supply lumen 67S

and a tubular return lumen 67R, and which may be used for delivery and return of cryogen. (Lumens 67S and 67R are illustrated in Fig. 3.) Thus, cryogen 72 contained in the storage unit may be delivered via supply lumen 66S and the proximal end, through the probe, to the distal end. Cryogen returns from the distal end via the probe and the proximal end and return lumen 66R to the storage unit.

[0048] During the procedure it is important that proximal termination 56 is not removed from connector 68. Such removal, typically inadvertent, may cause cryogen to escape from lumens 66S and 66R and/or proximal termination 56. Such an escape is a safety hazard. To prevent inadvertent removal, once the proximal termination has been inserted into the connector and mated with the lumens, a latch plate 76 in the connector automatically locks the proximal termination to the connector. As a further safety aspect, unlocking of the proximal termination from the connector, permitting removal of the proximal termination, may only be implemented positively, by simultaneous actuation of a button 80 and a latch plate retainer 84, the retainer being fixedly attached to the latch plate. The construction and operation of the latch plate in connector 68 is described in more detail with respect to Figs. 2A, 2B, below.

[0049] Figs. 2A and 2B are schematic drawings of connector 68, according to an embodiment of the present invention. The figures illustrate the connector in a number of different views, without proximal termination 56 being inserted into the connector. A callout "A" also illustrates two opposing faces 76A, 76B of latch plate 76, and a figure "B" illustrates a front view of the latch.

[0050] For clarity in the description herein, connector 68 is assumed to be drawn on a set of xyz orthogonal axes. In a disclosed embodiment, the z axis is assumed to be collinear with the axis of symmetry of lumen 67 and to have a positive direction that extends proximally and horizontally from section 66. Latch plate 76 is formed, in a disclosed embodiment, as a generally rectangular plate that is normal to the z axis, and that has edges that are assumed to be vertical and horizontal. The positive y axis is assumed to be parallel to a vertical edge of plate 76, directed up; the positive x axis is assumed to be parallel to a horizontal edge of plate, directed right when viewed distally along the z axis. An origin of the axes is assumed to reside in the plate. It will be appreciated that the orientations described herein are for clarity and by way of example, and that embodiments of the present invention may function in substantially any orientation.

[0051] Latch plate 76 is held between a connector base plate 88, lying in an xy plane, and a connector cover 92. In base plate 88 are two shoulders, 96A 96B, both parallel to the y-axis and protruding from the plate in a positive z-direction, separated by the width of the latch plate, and the latch plate is positioned between the shoulders. The shoulders constrain the plate to move in a slot 98, between the shoulders, parallel to the y-axis. (Because it is attached to plate 76, plate retainer 84 also moves parallel to the y-axis.

[0052] Latch plate 76 has two apertures formed within the plate: a generally slot-like aperture 100, parallel to the y-axis, and a generally oval aperture 104 which is penetrated by the z-axis. More details of the structure and the function of the apertures are given below.

[0053] A cylindrical rod 108 (shown also in cross-section in the figure), which is formed as a plurality of solid cylinders 108A, 108B, 108C, of different diameters, penetrates slot-like aperture 100. Cylinder 108A has two circular grooves 108A1, 108A2 formed in the cylinder. There is a shoulder 146 between cylinder 108A and cylinder 108B, and a shoulder 144 between cylinders 108B and 108C.

[0054] Aperture 100 has two different slots 102, 106, each slot having a depth that is half the thickness of plate 76. Slot 102 has two different widths, an upper part 110 and a lower part 114 having a width corresponding to the diameter of cylinder 108C, and a central part 122 having a width corresponding to the diameter of cylinder 108B. Slot 106 is in four different sections, an upper section 126 and a lower section 130, both terminating in a semicircle and having a width corresponding to the diameter of cylinder 108C, an upper middle section 134 having the diameter of cylinder 108B, and a partially circular lower middle section 138, having a diameter equal to the diameter of cylinder 108A. There is an internal surface 142 in plate 76, formed by the different widths of the two slots.

[0055] Button 80 connects to a proximal end of cylindrical rod 108. A distal end of the rod is held within a rod holder 112, which is fixed to base plate 88. The rod holder has a blind hole 116 having a diameter corresponding to the diameter of cylinder 108A of rod 108, and there is a spring 118 within the blind hole contacting the rod distal end, the spring pushing the rod in a positive z-direction. It will be appreciated that rod 108 is able to slide in hole 116 in a z-direction.

[0056] Rod holder 112 acts as a support for two printed circuit (PC) boards PC1, PC2. Board PC1 has two pairs of radiation transmitters TX1A, TX1B, and TX2A, TX2B, herein by way of example assumed to comprise infra-red emitters. Board PC2 has two pairs of receivers RX1A, RX1B, and RX2A, RX2B configured to receive the radiation transmitted by the transmitters. Herein by way of example the receivers are assumed to comprise phototransistors. There are four channels C1A, C1B, C2A, C2B, in holder 112, and transmitters TX1A, TX1B, TX2A, TX2B are aligned respectively with channels C1A, C1B, C2A, C2B and with receivers RX1A, RX1B, and RX2A, RX2B. Thus, absent any obstruction in the channels, radiation from the transmitters is received by, and activates the receivers.

[0057] As is described below, cylinder 108A does obstruct the channels, except when grooves 108A1 or 108A2 align with a channel.

[0058] As is explained further below, receivers RX1A, RX1B, RX2A, RX2B, act as sensors, and are also termed herein sensors RX1A, RX1B, RX2A, RX2B. Sensors

RX1A, RX1B, RX2A, RX2B detect, *inter alia,* the position of latch plate 76 in slot 98.

[0059] As stated above, latch plate 76 is constrained to move in a y-direction, in slot 98, by shoulders 96A, 96B. The plate is pushed in a positive y-direction by springs 120, which are held between plate retainer 84 and cover 92. In the state illustrated in Figs. 2A and 2B, i.e., where proximal termination 56 is not in the connector, the plate is prevented from moving in a y-direction by a semicircular section 124 of aperture 104 contacting a circular split lip 128 protruding in a z-direction from a latch backing disc 132. Disc 132 and split lip 128 are maintained in contact with plate 76 by springs 136, which push the disc in a positive z direction, and which permit the disc to move along the z axis.

[0060] In the situation illustrated in Figs. 2A and 2B, latch plate 76 is in its lowest possible y-position. In the illustrated situation an upper semicircular section 140 of section 126 mates with cylinder 108C of rod 108. In addition, by virtue of the force exerted in the positive z direction by spring 118 on rod 108, shoulder 144 between cylinder 108B and cylinder 108C is pushed against face 76B of plate 76. Consequently, rod 108 is fixed in a position where it is unable to move parallel to the z-axis. In this position, neither groove 108A1 nor groove 108A2 align with any of channels C1A, C1B, C2A, C2B. Rather, the channels are obstructed by cylinder 108A, so that none of sensors RX1A, RX1B, RX2A, RX2B, activate.

[0061] As is described below, in embodiments of the invention, plate 76 and rod 108 are in other positions, but in the situation illustrated in Figs. 2A and 2B, where there is nothing inserted in aperture 104, latch plate 76 is in its lowest possible y-position, and rod 108 is in its most distal position measured parallel to the z axis.

[0062] Fig. 3 is a schematic drawing of connector 68 when proximal termination 56 of probe 60 is inserted into the connector, according to an embodiment of the present invention. The figure illustrates the connector and the termination in a perspective view, substantially as shown in Fig. 1 and in a cross-section view. The figure also illustrates the connector in a perspective view.

[0063] Termination 56 fits within conduit 67, forming cylindrical supply lumen 67S and connecting to tubular return lumen 67R. Termination 56 has an axis of symmetry that, when it is in the conduit 67, is collinear with the z-axis. On insertion of termination 56 into opening 70, the termination pushes lip 128 and its latch backing disc 132 in a negative z-direction against springs 136, so that the lip disengages from semicircular opening 124. The disengagement permits latch plate 76 to move in a y-direction, and springs 120 push the plate in a positive y-direction.

[0064] Latch plate 76 moves in a positive y-direction until opening 124 engages with a circular groove 150 in termination 56. The engagement grips the termination, and locks it in place so that the termination may not be removed from opening 70, except as described below. Groove 150 has a radius R_1, and it will be appreciated that it is the value of R_1 that determines the location of latch plate 76 when termination 56 is in place, and so determines the distance moved by the latch plate when the termination is inserted into opening 70.

[0065] The vertical movement of latch plate 76 causes shoulder 144 of rod 108 to slide in slot-like aperture 100 against face 76B of the latch plate. While shoulder 144 slides against face 76B, the sliding continues until the slot that rod 108 is in enlarges, at section 134 (Fig. 2A); at this point spring 118 pushes rod 108 in a positive z-direction until shoulder 144 contacts internal surface 142.

[0066] The positive z-direction movement of rod 108 causes groove 108A2 to align with channels C2A and C2B, so that the channels are not obstructed. (Channels C1A and C1B are obstructed by cylinder 108A.) Consequently transmitters TX2A and TX2B activate respective sensors RX2A and RX2B. The sensor activation acts as a positive indication that termination 56 has been inserted into opening 70. The positive indication from the sensors may be used by delivery section 66 to recognize that it is safe to permit flow of cryogen from storage unit 64, and thus to activate the delivery section. As is described further below, deactivation of the sensors prevents cryogen flow.

[0067] To remove termination 56 from opening 70, the termination must be disengaged from latch plate 76. The disengagement requires the latch plate to move down, so that circular groove 150 is no longer gripped by the latch plate, but in the state illustrated in Fig. 3 this is not possible, since cylinder 108B contacts an upper part of upper middle section 134.

[0068] Embodiments of the invention provide a two step method for removal of termination 56. As a first step button 80 is pushed in, typically by one finger or a thumb of physician 24, so that cylinder 108B no longer contacts an upper part of upper middle section 134. Springs 120 still maintain the latch plate gripping groove 150, but the removal of contact between cylinder 108B and section 134, permits a second step.

[0069] In the second step, the physician uses a second of his/her digits to press down on plate retainer 84, so that latch plate 76 moves in a negative y-direction, and disengages from groove 150 of the termination. The physician may then remove the termination.

[0070] It will be understood that the first step, of pushing button 80 in, deactivates sensors RX2A and RX2B, by blocking the channels to the sensors. The sensor deactivation may be used to deactivate cryogen delivery section 66 of cryogen unit 64 and operation by processor 36 of pump 40, so preventing cryogen flow from the section and from the unit. It will also be understood that inadvertent pushing of button 80 and pressing retainer 84 deactivates sensors RX2A and RX2B, and thus halts cryogen flow by deactivating delivery section 66 and pump 40.

[0071] Fig. 4 is a schematic drawing of connector 68 when a sealing plug 200 is inserted into the connector, according to an embodiment of the present invention.

The figure illustrates the connector and the plug in a perspective view, substantially as shown in Fig. 1 and in a cross-section view. The figure also illustrates the connector in a perspective view.

[0072] When probe 60 is not in use, cryogen unit 64 may be sealed by plug 200, in order to prevent air and/or moisture entering the unit, as well as to reduce the evaporation of any cryogen in the unit, and to prevent any uncontrolled release of cryogen.

[0073] Plug 200 fits within lumen 67, being held in the lumen by an O-ring 204, and the plug has an axis of symmetry that, when it is in the lumen, is collinear with the z-axis. On insertion of plug 200 into opening 70, the plug pushes lip 128 and its latch backing disc 132 in a negative z-direction against springs 136, so that the lip disengages from semicircular opening 124. The disengagement permits latch plate 76 to move in a y-direction, and springs 120 push the plate in a positive y-direction.

[0074] Latch plate 76 moves in a positive y-direction until opening 124 engages with a circular groove 208 in plug 200. The engagement grips the plug, and locks it in place so that the plug may not be removed from opening 70, except as described below. Groove 208 has a radius R_2, and it will be appreciated that it is the value of R_2 that determines the location of latch plate 76 when plug 200 is in place, and so determines the distance moved by the latch plate when the plug is inserted into opening 70. In embodiments of the invention, R_1 and R_2 are configured to be different, and in the disclosed embodiment, $R_2 < R_1$.

[0075] For the case when $R_2 < R_1$, shoulder 144 initially slides as described above for termination 56 (Fig. 3). Because $R_2 < R_1$, the possible vertical motion of the latch plate is larger than is the case with the termination. Consequently latch plate 76 continues moving vertically upwards until rod 108 is able to enter central part 122 of slot 102 (Fig. 2A). When it enters the central section, spring 118 pushes the rod in a positive z-direction until shoulder 146 contacts face 76B of the latch plate. In this case cylinder 108B contacts an upper part of central section 122, and this contact prevents the latch plate from moving down.

[0076] The positive z-direction movement of rod 108 causes groove 108A1 to align with channels C1A and C1B, so that the channels are not obstructed. (Channels C2A and C2B are now obstructed by cylinder 108A.) Consequently transmitters TX1A and TX1B activate respective sensors RX1A and RX1B. The sensor activation acts as a positive indication that plug 200 has been inserted into opening 70.

[0077] Typically, when apparatus 20 is powered on, processor 36 checks, using sensors RX1A and RX1B that plug 200 is in place, so that, after removal of the plug, termination 56 of probe 60 may be inserted into the connector. In addition, on shutting down, processor 36 may check, using the sensors, that plug 200 is in place, so as to enable an orderly shutdown.

[0078] As for termination 56, embodiments of the invention provide a two step method for removal of plug 200. As a first step button 80 is pushed in, as for termination 56, typically by physician 24 using one of his/her digits. In the second step, which is now permitted since the first step enables the latch plate to be moved vertically, the physician uses a second digit to press down on plate retainer 84, so that latch plate 76 moves in a negative y-direction, and disengages from groove 208 of the plug. The physician may then remove the plug.

[0079] It will be understood that the first step, of pushing button 80 in, deactivates sensors RX1A and RX1B, by blocking the channels to the receivers.

[0080] It will be appreciated that the embodiments described above are cited by way of example, and that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and modifications thereof which would occur to persons skilled in the art upon reading the foregoing description and which are not disclosed in the prior art.

Claims

1. A cryogenic apparatus, comprising:

a connector comprising:

a connector base plate configured for connection to a conduit carrying a cryogen, and a slot extending across the base plate;

a plug, which is configured for insertion into an opening in the base plate;

a latch plate configured to slide within the slot between a first position, in which the plug is inserted through an aperture in the latch plate into the opening, and a second position, in which a cryogenic probe is inserted through the aperture and brought into fluid communication with the opening; and

a sensor, which is coupled to control a flow of the cryogen through the conduit by detecting whether the latch plate is in the first position or the second position.

2. The cryogenic apparatus according to claim 1, wherein the plug comprises a groove, and wherein the aperture grips the groove, when the plug is inserted through the aperture, so as to lock the plug to the latch plate.

3. The cryogenic apparatus according to claim 1, wherein the cryogenic probe comprises a groove, and wherein the aperture grips the groove, when the probe is inserted through the aperture, so as to lock the probe to the latch plate.

4. The cryogenic apparatus according to any of claims 1-3, and comprising a control rod which penetrates a further aperture in the latch plate and which is configured to operate the sensor.

5. The cryogenic apparatus according to any of claims 1-3, and comprising a control rod which penetrates a further aperture in the latch plate and which, when the latch plate is in the first position, is in a first control rod position that deactivates the sensor so as to prevent flow of the cryogen, and when the latch plate is in the second position, is in a second control rod position that activates the sensor so as to permit flow of the cryogen.

6. The cryogenic apparatus according to any of claims 1-3, and comprising a control rod which penetrates a further aperture in the latch plate and which, when the latch plate is in the first position, is in a first control rod position that prevents the latch plate from moving from the first position, and when the latch plate is in the second position, is in a second control rod position that prevents the latch plate from moving from the second position.

7. The cryogenic apparatus according to claim 6, wherein the control rod, when translated from the first control rod position permits the latch plate moving from the first position, and, when translated from the second control rod position permits the latch plate moving from the second position.

8. A method, comprising:

providing a connector comprising:

a connector base plate configured for connection to a conduit carrying a cryogen, and a slot extending across the base plate;

configuring a plug for insertion into an opening in the base plate;
sliding a latch plate within the slot between a first position, in which the plug is inserted through an aperture in the latch plate into the opening, and a second position, in which a cryogenic probe is inserted through the aperture and brought into fluid communication with the opening; and
coupling a sensor to control a flow of the cryogen through the conduit by detecting whether the latch plate is in the first position or the second position.

9. The method according to claim 8, wherein the plug comprises a groove, and wherein the aperture grips the groove, when the plug is inserted through the aperture, so as to lock the plug to the latch plate.

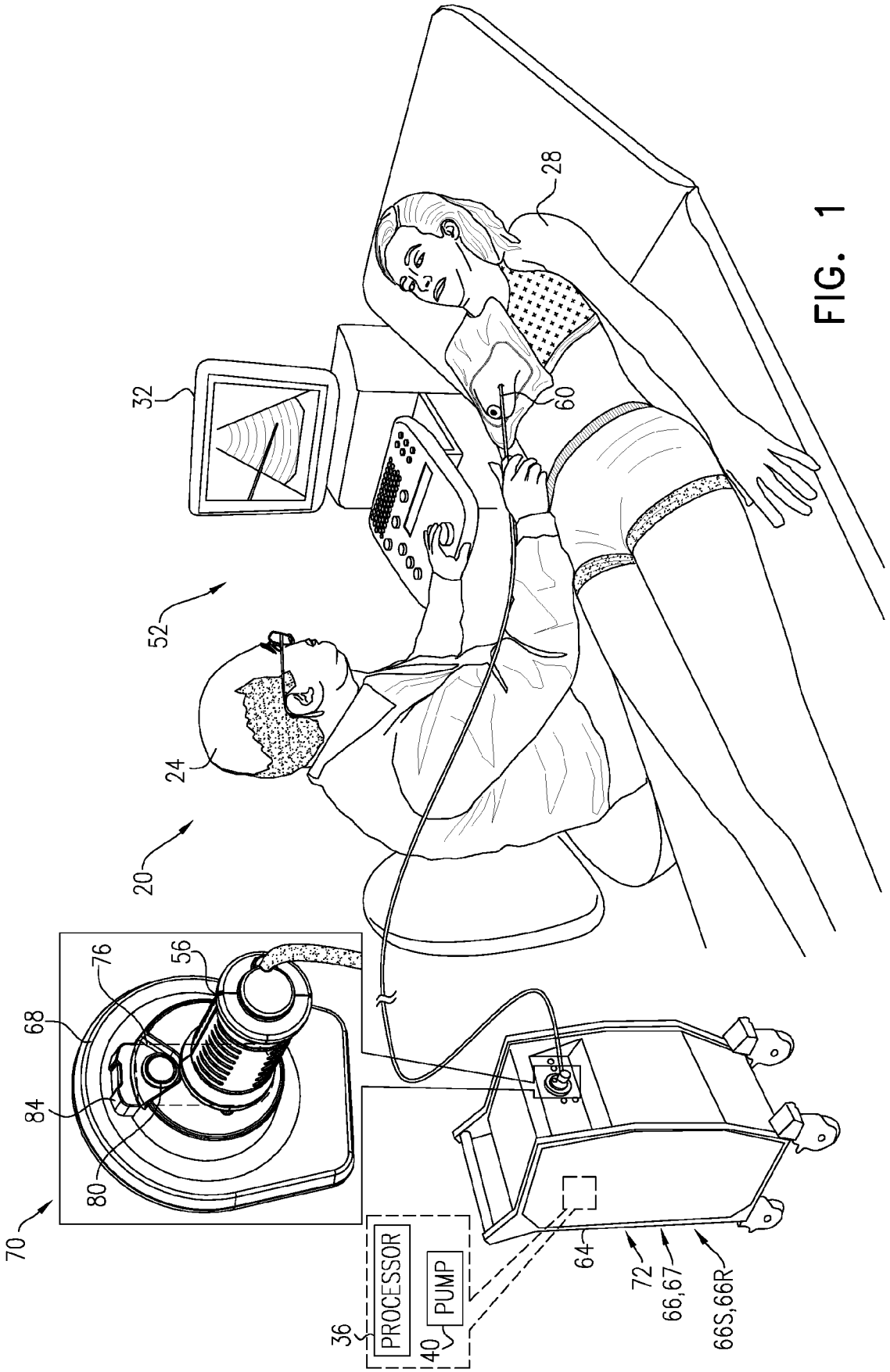
10. The method according to claim 8, wherein the cryogenic probe comprises a groove, and wherein the aperture grips the groove, when the probe is inserted through the aperture, so as to lock the probe to the latch plate.

11. The method according to any of claims 8-10, and comprising providing a control rod which penetrates a further aperture in the latch plate and which is configured to operate the sensor.

12. The method according to any of claims 8-10, and comprising providing a control rod which penetrates a further aperture in the latch plate and which, when the latch plate is in the first position, is in a first control rod position that deactivates the sensor so as to prevent flow of the cryogen, and when the latch plate is in the second position, is in a second control rod position that activates the sensor so as to permit flow of the cryogen.

13. The method according to any of claims 8-10, and comprising providing a control rod which penetrates a further aperture in the latch plate and which, when the latch plate is in the first position, is in a first control rod position that prevents the latch plate from moving from the first position, and when the latch plate is in the second position, is in a second control rod position that prevents the latch plate from moving from the second position.

14. The method according to claim 13, wherein the control rod, when translated from the first control rod position permits the latch plate moving from the first position, and, when translated from the second control rod position permits the latch plate moving from the second position.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60
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24
20
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80
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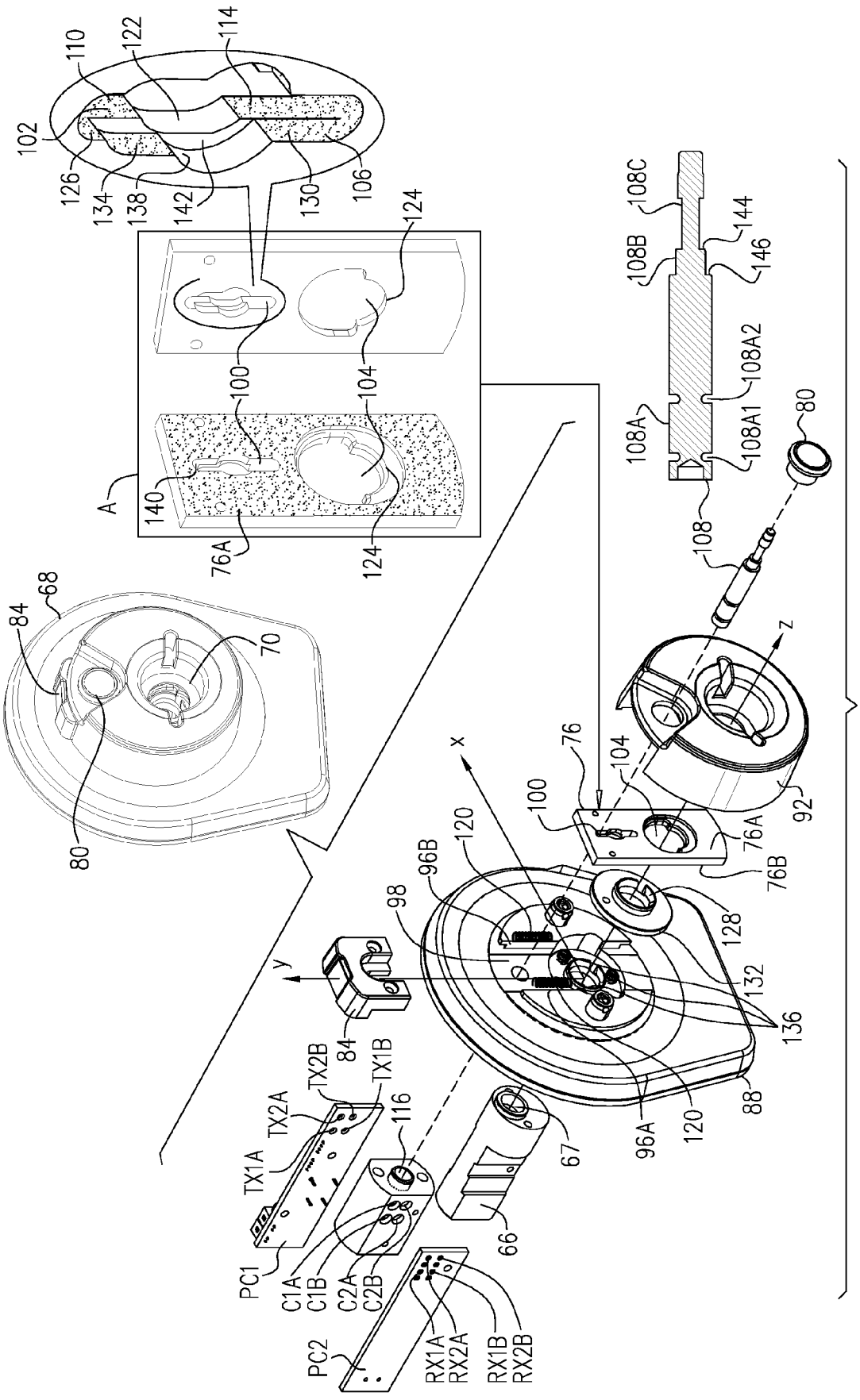
PROCESSOR
PUMP
36
40
64
72
66,67
66S,66R

FIG. 1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142
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124
100
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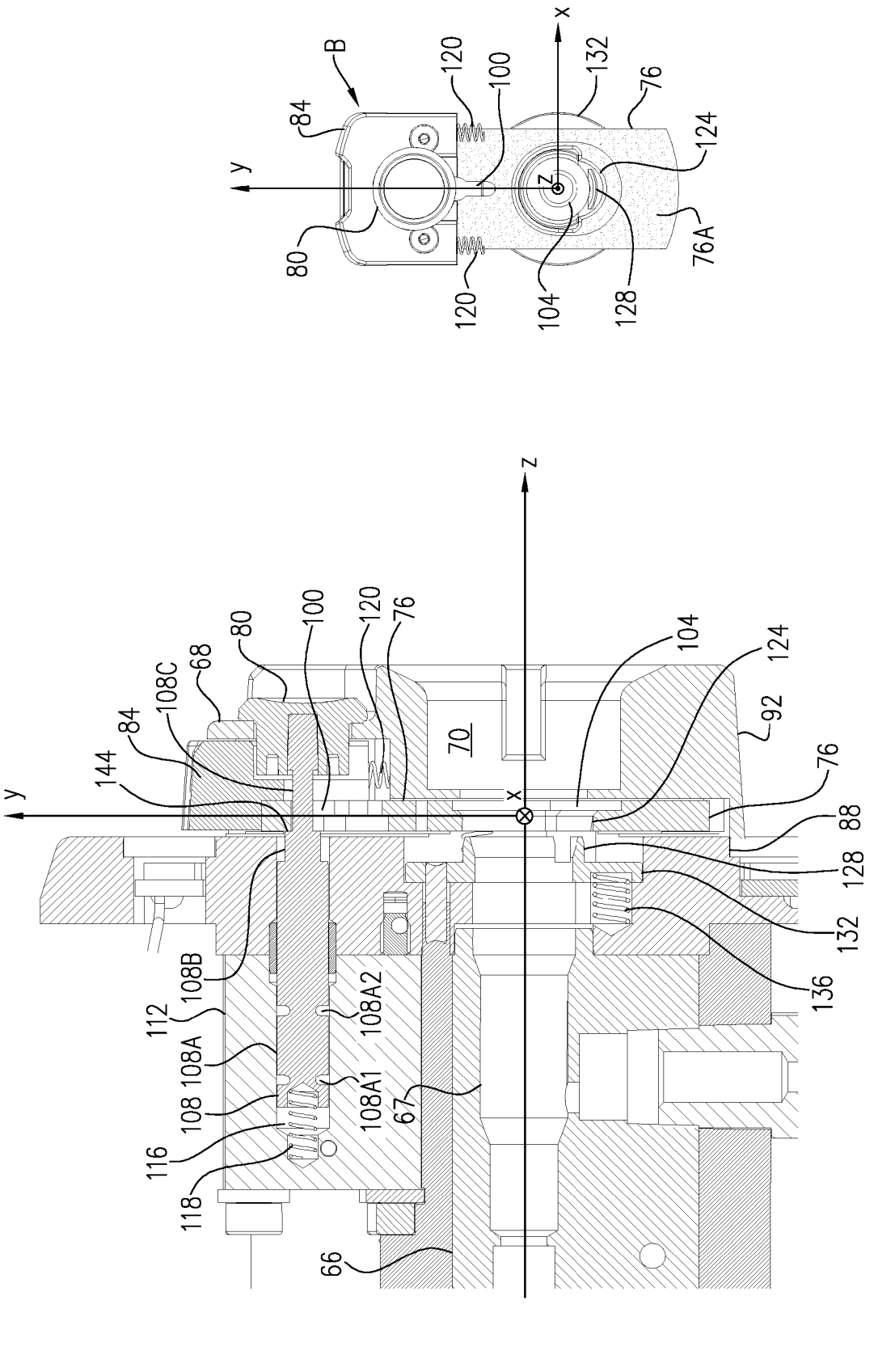
108C
108B
144
146
108A2
108A1
108A
80
108
z
92
76
104
100
76A
76B
x
120
96B
98
128
132
136
88
96A
120
67
66
y
84
TX2B
TX1B
TX2A
TX1A
116
PC1
C1A
C1B
C2A
C2B
PC2
RX1A
RX2A
RX1B
RX2B
68
84
70
80

FIG. 2A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y
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76A
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108C
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120
76
104
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92
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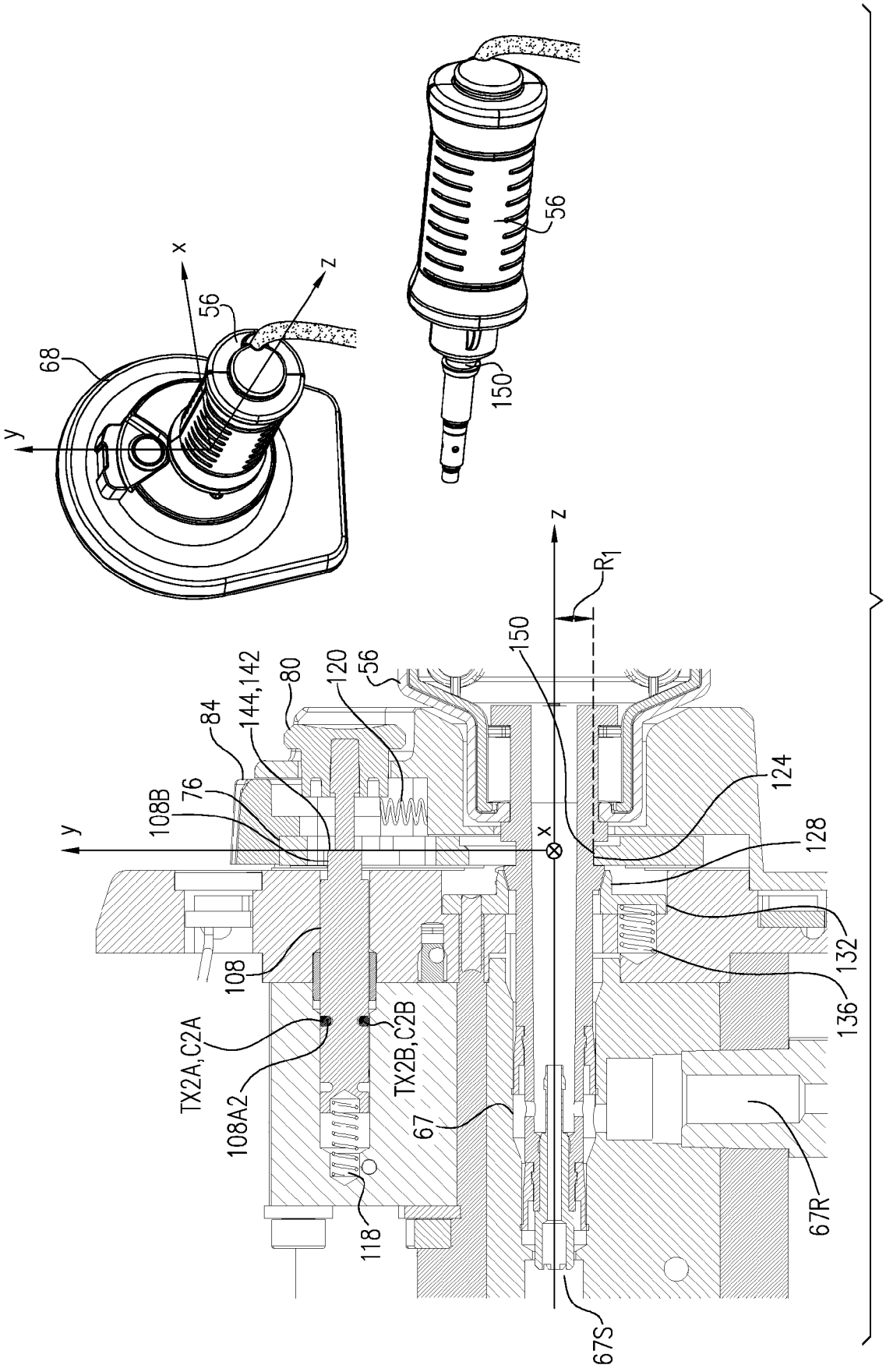
88
108B
112
108A
108
116
118
108A2
108A1
67
66
136

FIG. 2B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150
z
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144,142
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76
108B
y
x
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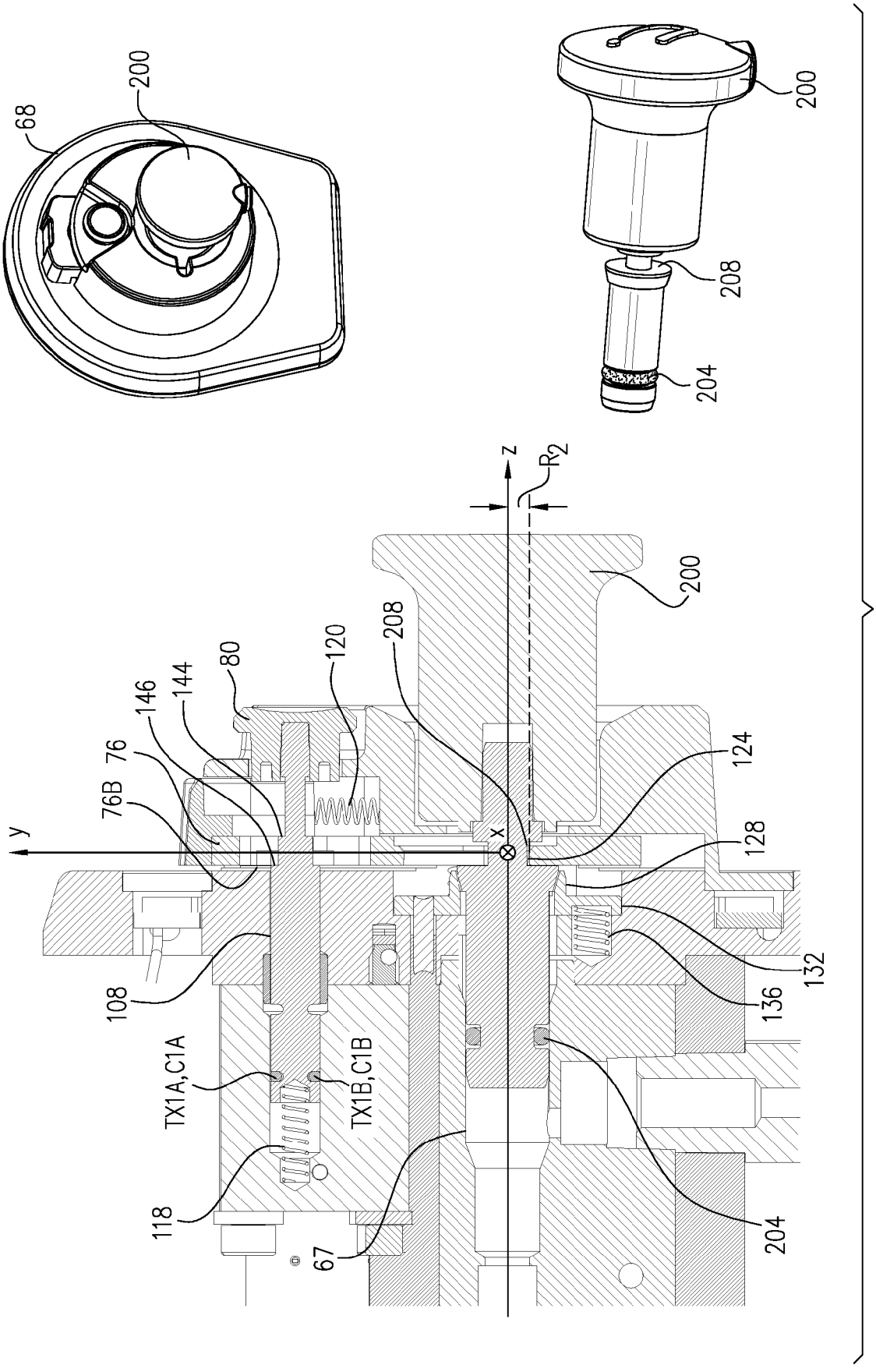
128
132
136
108
TX2A,C2A
108A2
TX2B,C2B
67
118
67R
67S

FIG. 3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200
200
208
204
z
R_2
200
208
120
80
146
144
76
76B
y
x
124
128
132
136
108
TX1A,C1A
TX1B,C1B
118
67
204

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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